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IMPACT OF INSECTS ON MULTIPLE-USE VALUES OF NORTH CENTRAL FORESTS: AN EXPERIMENTAL RATING SCHEME

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IMPACT OF INSECTS ON MULTIPLE-USE VALUES OF NORTH-CENTRAL FORESTS: AN EXPERIMENTAL RATING SCHEME

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To establish priorities for research requires that problems be ranked according to their importance. Up to now, no rigorous basis for ranking forest insect problems has been available. We thought more accurate and precise ranking might result if a scheme were devised to systematize the use of many inputs that otherwise enter subjectively or not at all into ranking decisions. The scheme we introduce and demonstrate here numerically evaluates the importance of different insects to the multiple uses of forests on a regionwide, historical scale. It is not a formula for assessing current impact in a local situation, nor is it adequate for gauging the enormously important roles of purely beneficial insects like pollinators and scavengers. It has undergone several revisions and can no doubt be improved further. We offer it now for wider discussion and testing.

The traditional concept of forest insects emphasizes those that hinder wood production. The scheme enlarges this concept by considering more fully the role insects play in the forest. It recognizes that insects have positive as well as negative effects and that processes basic to the function and use of the forest as a whole are involved. The result is an ecosystem view of forest insects and a clear implication that the importance of insects cannot be evaluated adequately unless they are considered in an ecosystem context.

For evaluation purposes, problem units may be either single insect species or groups of taxonomically or ecologically similar species. Each unit to be rated is moved through the four parts of the scheme: one part each for timber, recreation, wildlife, and water. Each part consists of statements requiring a response based on factual information about the unit being evaluated. Responses have a corresponding score value. Where a unit does not fit well into any response category, a score midway between two categories may be assigned. All statements are understood to refer to the entire north-central region – the States of Minnesota, Wisconsin, Michigan, Iowa, Missouri, Illinois, and Indiana. Similar schemes for other areas could be developed.

Total score for each part is an arithmetic function of the various individual scores. Score computations were built in according to the additive or multiplicative character of the factors considered as well as overall scaling. The highest total score for any one part is 10. The score for the four multiple-use elements is obtained by adding score totals from the four parts. This amounts to equal weighting of the parts. If the user wishes, he can weight the multiple-use elements differently by simply multiplying part score totals by factors of his choosing before summing to get the grand total.

As an example of the system described, we illustrate our scoring for the forest tent caterpillar by circling individual scores and showing resulting arithmetic in bold face type.

PART I: TIMBER

Insects may kill trees, retard growth, or mar wood and tree form. These are mainly consequences of direct attacks that consist of foliage consumption, bud mining, wood boring, root destruction, and others. Indirect effects, such as seed eating, which might affect natural regeneration, are less understood. Part 1 of the scheme is concerned chiefly with direct effects on timber crops.

Score

1. Value of standing timber affected (in millions of dollars, see table 1):

a.	Less than 50	1
b.	51 to 100	2
c.	101 to 200	(3)
d.	201 to 500	4
e.	Over 500	5

2. Percent of growing stock attacked during an outbreak or other typical infestation period:

a.	Less than 1	1
b.	1 to 5	2
c.	6 to 10	3
d.	11 to 20	4
e.	Over 20	(5)

3a. If characterized by outbreaks, the number per century is:

Score

a.	1	1
b.	2	2
c.	3 to 5	3
d.	6 to 9	(4)
e.	Over 9	5

3b. If characterized as continuous, with no definite outbreak periods, the number of problem years during a crop rotation is:

a.	Less than 6	1
b.	6 to 15	2
c.	16 to 30	3
d.	31 to 50	4
e.	Over 50	5

4. Usual percentage of the stand affected (mortality or reduction in growth or quality) during an outbreak or other typical infestation period is:

a.	Less than 6	1
b.	6 to 15	(2)
c.	16 to 30	3
d.	31 to 50	4
e.	Over 50	5

Multiply scores of items 1 and 2. Multiply scores of items 3 (a or b) and 4. Add the two products and divide sum by 5. Record quotient as score for Part 1 and go to Part 2: Recreation.

3×5=15. 4×2=8. 15+8=23. 23÷5=4.6.

Table 1.—Approximate value of standing timber by species and species groups, North Central States

Species or group	Volume[1]	Stumpage value: Per cubic foot[2]	Stumpage value: Total
	Million cubic feet	Dollars	Million dollars
Eastern cottonwood, quaking aspen, and similar species	8,377.8	0.023	192.7
Sugar maple	3,723.9	.166	618.2
White oak and similar species	3,447.5	.139	479.2
White spruce and balsam fir	3,296.4	.070	230.7
Black and northern red oaks	3,166.1	.125	395.8
Red and silver maples and boxelder	2,291.7	.100	229.2
White and black ashes	1,971.9	.113	222.8
Red and eastern white pines	1,726.1	.134	231.3
Jack pine	1,494.9	.053	79.2
American basswood	1,482.9	.156	231.3
Shagbark, pignut, and other hickories	1,428.1	.089	127.1
Eastern hemlock	897.3	.057	51.1
Yellow birch	731.2	.256	187.2
American beech	622.3	.093	57.9
Black walnut	294.9	.484	142.7

[1] Net volume of growing stock on commercial forest land, January 1, 1968.

[2] Stumpage value calculated from early 1968 prices in north-central region. Stumpage value per million board feet/160 = cubic foot value.

PART 2: RECREATION

Insects may affect forest recreation directly in two ways: by annoying recreationists and damaging vegetation important to recreational activities. In the first category, insects may bite, contaminate food or habitations, or offend in other ways. Some are capable of transmitting disease if other epidemiological requisites are present. As damagers of vegetation, insects mar the utility, quality, and beauty of sites such as campgrounds, vistas, and trails. Through their effects on wildlife, they are also indirectly related to forest recreation in such activities as hunting and bird study. This interaction of multiple-use elements is not taken into account, however. Insect effects on wildlife are evaluated separately in Part 3 of the scheme.

In Part 2 of the scheme, an insect unit can be evaluated in either or both categories A and B, depending on its habits. One that primarily affects vegetation must be evaluated under category B either as an outbreak or continuous type, not both.

A. Direct Annoyance

Score

1. Degree of annoyance:
   - a. Rarely offensive to humans in any way. 0
   - b. Offensive only because present incidentally where not wanted, as during an outbreak. (1)
   - c. Contaminates food, habitations; may breed in filth; may be repugnant for reasons other than direct attack. 2
   - d. Irritates skin by biting, stinging, or other physico-chemical attack. 4
2. Disease vector potential:
   - a. Absent (0)
   - b. Present 2

Score

3. Time of year active:
   - a. Before June 15 or after September 1. 1
   - b. Less than half of period between June 15 and September 1. (2)
   - c. More than half of period between June 15 and September 1. 3
4. Acres of forest affected:
   - a. Less than 100,000 1
   - b. 100,000 to 500,000 2
   - c. 500,000 to 1 million 3
   - d. 1 to 10 million (4)
   - e. Over 10 million 5

Multiply scores of items 1 and 3, 1 and 4, 2 and 3, and 2 and 4. Add the four products. If insect feeds primarily on man and animals, divide score by 4.8. Quotient is final score for recreation. If insect feeds primarily on vegetation, do not divide by 4.8; instead, hold sum as partial score and go to category B.

$1\times2=2$. $1\times4=4$. $0\times2=0$. $0\times4=0$.
$2+4+0+0=6$.

B. Damage to Vegetation Basic to Pursuit of Recreation

Score

If characterized by outbreaks, go to item 1. If characterized as continuous, with no definite outbreak periods, go to item 6.

OUTBREAK INSECTS

1. Usual percentage of stand killed:
   - a. Less than 2 1
   - b. 2 to 9 (2)
   - c. 10 to 25 3
   - d. Over 25 4

	Score
2. Usual forest area affected (acres):	
a. Less than 100,000	1
b. 100,000 to 500,000	2
c. 500,000 to 1 million	3
d. Over 1 million	(4)
3. Number of outbreaks per century:	
a. 1	1
b. 2	2
c. 3 to 5	3
d. 6 to 9	(4)
e. Over 9	5
4. Number of outbreak years per century (number of outbreaks x typical duration of outbreaks in years):	
a. Less than 10	1
b. 10 to 19	2
c. 20 to 30	3
d. Over 30	(4)
5. Time of growth season when injury culminates:	
a. Last 1/3	1
b. Middle 1/3	(2)
c. First 1/3 (if refoliation occurs same growth season, use score for *b*)	3

Multiply scores of items 1, 2 and 3. Multiply scores of items 4 and 5. Add the two products. Now add score from category A. Divide new sum by 14. Record quotient as score for Part 2 and go to Part 3: Wildlife.

$2\times4\times4=32$. $4\times2=8$. $32+8=40$. $40+6=46$. $46\div14=3.3$.

CONTINUOUSLY DAMAGING INSECTS

	Score
6. Usual effect (immediate and residual) on individual host:	
a. Negligible	0
b. Branch mortality or breakage	1
c. Decline: higher than normal probability of death and breakage	2
7. Percent of host species in cover type:	
a. Less than 1	1
b. 1 to 5	2
c. 6 to 20	3
d. Over 20	4
8. Valuation of host species (see table 2):	
a. Low	1
b. High	2

Table 2.–Relative value of some common native tree species in a recreation context [1]

High	Low	High	Low
American beech	American basswood	Pin oak	Silver maple
Black walnut	American elm	Red maple	
Bur oak	American sycamore	Red pine	
Eastern hemlock	Bigtooth aspen	Scarlet oak	
Eastern white pine	Black cherry	Sugar maple	
Flowering dogwood	Boxelder	White ash	
Green ash	Eastern cottonwood	White oak	
Northern red oak	Jack pine	Yellow-poplar	
Paper birch	Quaking aspen		

1/ Compiled mostly from: National Shade Tree Conference. Shade tree evaluation. 14 p. 1957.

Score

9. Percentage of forested area affected:

a.	Less than 10	1
b.	10 to 30	2
c.	Over 30	3

Multiply scores of items 6 through 9. Divide product by 4.8. Record quotient as score for recreation and go to Part 3: Wildlife. (Normally, vegetation damagers of the continuous type have zero score from category A.)

PART 3: WILDLIFE

Insects influence wildlife in three major ways: as parasites, wildlife food, and disruptors of wildlife habitat. The parasite and food roles are obvious, but modification and disruption of the habitat are more complex. For example, the effect of severe defoliation can be beneficial for some animals while detrimental to others. The scheme attempts to quantify the modification or disruption rather than evaluate the effect on any specific animal.

This part of the scheme requires that an insect unit be evaluated in two of three categories. Insects parasitic on animals, such as mosquitoes, would be evaluated in categories A and B. Insect units such as defoliators would be evaluated in categories B and C.

A. Parasitic Insects

Score

1. Degree of annoyance:

a.	Low	1
b.	Medium	2
c.	High	4

Score

2. Usual number of weeks per year active:

a.	Less than 5	1
b.	5 to 9	2
c.	10 to 14	3
d.	Over 14	4

3. Insect potential to vector pathogens:

a.	Negligible	1
b.	Low	2
c.	Moderate	4

4. Percent forest area affected:

a.	Less than 25	1
b.	26 to 50	2
c.	51 to 75	3
d.	Over 75	4

Multiply scores of items 1 and 2. Multiply scores of items 3 and 4. Add products. Hold sum as partial score. Further scoring instructions appear at end of Part 3.

B. Wildlife Food

Score

1. Mature feeding stage less than ¼ inch long; or possesses protective mechanism such as undesirable taste or odor:

a.	Yes	1
b.	Maybe	2
c.	No	(4)

2. Usual number of weeks available as food (period when it is more than ¼ inch long; or, if less than ¼ inch, is aggregated into conspicuous colonies or masses):

a.	Less than 5	1
b.	5 to 10	(2)
c.	11 to 20	3
d.	Over 20	4

Score

3. Vertical distribution during stages susceptible to predation:

a. Canopy of dominant and codominant trees	One of these	1
b. Canopy of subdominants	Two of these	2
c. Shrubs or boles of trees	Three of these	3
d. Herbaceous vegetation, ground, or water	All of these	(4)

4. Usual number of years present per decade in at least moderate numbers (more than 10,000 per acre):

a. Less than 3	½
b. 3 to 5	(1)
c. 6 to 8	1½
d. Over 8	2

5. Forest area occupied by at least moderate numbers in any one year (acres):

a. Less than 500,000	½
b. 500,000 to 2 million	(1)
c. 2 to 4 million	1½
d. Over 4 million	2

Multiply scores of items 1 and 2. Add scores of 4 and 5. Multiply score of item 3 by sum of scores for items 4 and 5. Add products. Hold sum as partial score. Further scoring instructions appear at end of Part 3.

4×2=8. 1+1=2. 4×2=8. 8+2+8=18.

C. Disruption of Habitat

Score

1. Position of host plants in habitat:

a. Subdominant	1
b. Codominant	2
c. Dominant	3
d. More than one of above	(4)

Score

2. Percent recovery of host plants from outbreaks or other infestation periods:

a. Over 90	(1)
b. 75 to 90	2
c. 50 to 74	3
d. Less than 50	4

3. Number of outbreak years per century (number of outbreaks x typical duration of outbreaks in years):

a. Less than 10	1
b. 11 to 20	2
c. 21 to 30	3
d. Over 30	(4)

4. Usual size of outbreak area, or area otherwise occupied (acres):

a. Less than 500,000	1
b. 500,000 to 1 million	2
c. 1 to 3 million	(3)
d. Over 3 million	4

Multiply scores of items 1 and 2. Multiply scores of items 3 and 4. Add products. Hold sum as partial score. Go to final scoring instructions below.

4×1=4. 4×3=12. 4+12=16.

Final score for Part 3: If insect unit being evaluated is parasitic, add scores from categories A and B and divide by 6. If not parasitic, add scores from B and C and divide by 6. Record sum as score for Part 3 and go to Part 4: Water.

18+16=34. 34÷6=5.7.

PART 4: WATER

Insects may alter conditions that affect runoff, nutrient concentration, and evapotranspiration in forests. Frequency of floods resulting from rainfall during the growing season is a key hydrologic factor in evaluating insect impact on forest watersheds. This part is therefore divided into two categories: one for low flood frequency zones and one for high flood frequency zones (fig. 1). Each insect unit is to be evaluated in both categories on the basis of its geographic distribution in each zone.

	Score	
	High flood frequency	*Low flood frequency*
1. Size of area affected during outbreak or other infestation period (acres):		
a. Less than 100,000	(1)	1
b. 100,000 to 500,000	3	3
c. 500,000 to 1 million	5	5
d. More than 1 million	10	(10)
2. Recovery of host plants from defoliation or other damage:		
a. Refoliates same year	(½)	(1)
b. Does not refoliate same year	1	½
3. Usual percent of host defoliation during outbreaks or other periods:		
a. Less than 20	2	10
b. 20 to 39	4	8
c. 40 to 59	6	6
d. 60 to 80	8	4
e. More than 80	(10)	(2)
4. Typical duration of outbreak or other infestation period (years):		
a. Less than 2	1	1
b. 2 to 4	(3)	(3)
c. Over 4	5	5

Figure 1.—Zones of the north-central region having frequent severe floods. The shaded portions represent 10-year frequency flood twice normal annual flood. Generalized by D. H. Urie after U. S. Geological Survey Water Supply Papers 1675-1678 and 1680.

Make the following computations separately for each flood frequency: Multiply scores of items 2 and 3. Multiply scores of items 2 and 4. Add the two products. Multiply sum by score of item 1. Divide this product by 15. Add the quotients thus obtained for each flood frequency. The sum is the total score for Part 4.

High: $\frac{1}{2} \times 10 = 5$. $\frac{1}{2} \times 3 = 1\frac{1}{2}$. $5 + 1\frac{1}{2} = 6\frac{1}{2}$. $6\frac{1}{2} \times 1 = 6\frac{1}{2}$. $6\frac{1}{2} \div 15 = 0.4$.

Low: $1 \times 2 = 2$. $1 \times 3 = 3$. $2 + 3 = 5$. $5 \times 10 = 50$. $50 \div 15 = 3.3$. $0.4 + 3.3 = 3.7$.

Compute grand score for the unit by adding the total scores from each of the four parts of the scheme.

$4.6 + 3.3 + 5.7 + 3.7 = 17.3$

We have scored and ranked some prominent insects of north-central forests (table 3). Final scores have meaning only relative to other insects. The user may temper his evaluation of the scores with additional knowledge not considered in the scheme. Also, a particular mulitple-use value may be weighted according to the user's choosing. We believe that the system results in a better perspective of insects as important elements of forest ecosystems.

Table 3.—Some insects of north-central forests in descending order of their scores on the evaluation scheme [1]

Insect unit	Score				
	Timber	Recreation	Wildlife	Water	Total
Forest tent caterpillar (Malacosoma disstria)	4.6	3.3	5.7	3.7	17.3
Spruce budworm (Choristoneura fumiferana)	5.8	3.2	4.7	1.5	15.2
Aedes mosquitoes (Aedes spp.)	0	7.5	5.1	0	12.6
Larch sawfly (Pristiphora erichsonii)	3.4	2.4	4.9	.8	11.5
Maple bud miners (Proteoteras moffatiana & Obrussa ochrefasciella)	7.4	1.3	1.9	0	10.6
Poplar borer (Saperda calcarata)	4.2	3.3	2.5	.6	10.6
Deerflies (Chrysops spp.)	0	7.5	3.0	0	10.5
Jack-pine budworm (Choristoneura pinus)	3.2	2.3	4.0	.7	10.2
Pine tussock moth (Dasychira plagiata)	4.8	1.6	3.0	.2	9.6
Large aspen tortrix (Choristoneura conflictana)	2.0	1.7	2.5	.6	6.8
Pine engraver (Ips pini)	1.4	3.3	1.3	.2	6.2
Hemlock looper (Lambdina fiscellaria)	1.2	.6	3.6	.7	6.1
Walkingstick (Diapheromera femorata)	1.6	.7	3.3	.4	6.0
Red-pine cone beetle (Conophthorus resinosae)	2.0	0	.9	0	2.9

[1] Much basic information used for evaluating some of these insects is assembled in the following unpublished file report: Batzer, H. O. A problem analysis for research on the ecology of defoliating insects of natural forest stands in the north-central States. 40 p. 1967.

SOME RECENT RESEARCH PAPERS OF THE NORTH CENTRAL FOREST EXPERIMENT STATION

Relation Between the National Fire Danger Spread Component and Fire Activity in the Lake States, by Donald A. Haines, William A. Main, and Von J. Johnson. USDA Forest Serv. Res. Pap. NC-41, 8 p., illus. 1970.

Thinning and Fertilizing Red Pine to Increase Growth and Cone Production, by John H. Cooley. USDA Forest Serv. Res. Pap. NC-42, 8 p., illus. 1970.

The Impact of Estimation Errors on Evaluations of Timber Production Opportunities, by Dennis L. Schweitzer. USDA Forest Serv. Res. Pap. NC-43, 18 p., illus. 1970.

User Evaluation of Campgrounds on Two Michigan National Forests, by Robert C. Lucas. USDA Forest Serv. Res. Pap. NC-44, 15 p., illus. 1970.

System Identifiication Principles in Studies of Forest Dynamics, by Rolfe A. Leary. USDA Forest Serv. Res. Pap. NC-45, 38 p., illus. 1970.

Skiing in the Great Lake States: The Industry and the Skier, by William A. Leuschner. USDA Forest Serv. Res. Pap. NC-46, 42 p., illus. 1970.

Proceedings of the Ninth Lake States Forest Tree Improvement Conference, August 22-23, 1969. USDA Forest Serv. Res. Pap. NC-47, 34 p. 1970.

A Water Curtain for Controlling Experimental Forest Fires, by Von J. Johnson. USDA Forest Serv. Res. Pap. NC-48, 7 p., illus. 1970.

Wilderness Ecology: A Method of Sampling and Summarizing Data for Plant Community Classification, by Lewis F. Ohmann and Robert R. Ream. USDA Forest Serv. Res. Pap. NC-49, 14 p., illus. 1970.

Predicting Lumber Grade Yields for Standing Hardwood Trees, by Charles L. Stayton, Richard M. Marden, and Glenn L. Gammon, USDA Forest Serv. Res. Pap. NC-50, 8 p. 1971.

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